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of the

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Box 42, Schermerhorn Hall, Columbia University, New York, N.Y.

Editor
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Bibliographer
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Studies of South American plants. II. New Loranthaceae and Monimiaceae from the northern Andes

ALBERT C. SMITH

In the accompanying paper specimens from several herbaria are cited. The location of specimens is indicated by the following abbreviations: Botanisches Museum, Berlin-Dahlem (B); Conservatoire Botanique, Geneva (C); Royal Botanic Gardens, Kew (K); U. S. National Museum (N); New York Botanical Garden (Y).

LORANTHACEAE

Aetanthus colombianus sp. nov. Frutex parasiticus; ramis ramulisque subtriangularibus glabris crassis subrugosis; petiolis crassis rugosis anguste alatis ad 2 cm. longis; laminis crasse coriaceis ovato- vel obovato-ellipticis, 6–12 cm. longis, 2.5–7 cm. latis, basi attenuatis, apice rotundatis, margine integris, utrinque glabris et dense stomatiferis, pinnatinerviis, nervis secundariis 3–5-jugis adscendentibus utrinque leviter elevatis vel haud conspicuis; floribus in pseudocymis axillaribus dispositis; pedunculis primariis et secundariis 5–7 mm. longis, bracteis minute deltoideis; pedicellis binis 3–4 mm. longis; cupula subpatelliformi margine cartilaginea apice 3–4 mm. diametro; calyculo cylindrico apice patulo minute lobato, circiter 5 mm. longo, sub anthesi 1.5–2 mm. diametro; perigonio cylindrico carnoso coccineo, saepe distaliter luteo, maturitate 8–9.5 cm. longo, basi 1.5–2 mm. diametro, ad medium 6-lobato, lobis linearibus recurvatis, basi circiter 1.7 mm. latis, apice acutis; filamentis carnosis glabris prope basin loborum adfixis, 12–18 mm. longis; antheris erectis linearibus basifixis, 13–16 mm. longis, apice acutissimis et membranaceis, loculis eseptatis, ventralibus quam dorsalibus paullo longioribus, basi minute sagittato-divaricatis; stylo filiformi, stigmate ellipsoideo minute papilloso.

Type, *Killip & Smith 20583*, collected Mar. 12, 1927, along edge of woods on the eastern slope of Páramo del Hatico, between Pamplona and Toledo, Department of Norte de Santander, Colombia, alt. 2900 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicate at N. Other collections, all from Colombia at altitudes of 2900–3600 meters, are: Norte de Santander: Páramo de Almuerzadero, *Linden 1348* (C). Ocaña, *Kalbreyer 438* (K). Santander: Western slope of Páramo Rico, *Killip & Smith 17795* (N, Y). La Baja, *Funck & Schlim 1406* (C); *Killip & Smith 18127* (N, Y). East of Las Vegas, *Killip & Smith 15810* (N, Y). It is a species of the section *Euaetanthus* Engl., related to *A. Mutisii* (H.B.K.) Engl., which has flowers 20 cm. long or more. The leaves of our species are proportionately narrower, but leaves throughout the genus are

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very variable. The Peruvian *A. ornatus* Krause, the only other described species of this alliance, also has flowers longer than ours and leaves uniformly smaller.

Psittacanthus verticillatus sp. nov. Frutex parasiticus; ramulis subteretibus rugosis glabris, ad nodos incrassatis articulatis verticillatis, eis minoribus cum foliis saepe deciduis; petiolis incrassatis rugosis anguste alatis ad 8 mm. longis; laminis crasse coriaceis obovato-oblongis, 5–8 cm. longis, 3–5 cm. latis, basi attenuatis, apice rotundatis, margine integris, utrinque glabris et dense stomatiferis, obscure pinnatinerviis, nervis secundariis 2–4-jugis e costa prope basin saepe orientibus adscendentibus, cum costa haud conspicuis; inflorescentiis brevibus ad nodos dense aggregatis, ubique partibus exterioribus minute cinereo-pulverulentis, mox glabrescentibus; pedunculis subrugosis 3–7 mm. longis, bracteis parvis deltoideis; pedicellis binis 2–3 mm. longis; cupula patelliformi margine irregulari apice 3–4 mm. diametro; calyculo campanulato-cylindrico apice patulo margine irregulari, sub anthesi 6–7 mm. longo et 2.5–3 mm. diametro; perigonio cylindrico carnoso coccineo, maturitate 6–8.5 cm. longo, inferne circiter 2 mm. diametro, ad medium 6-lobato, lobis linearibus recurvatis, circiter 1.5 mm. latis, apice subacutis, margine ventrali crenatis; filamentis carnosis glabris circiter 25 mm. infra apicem perigonii adfixis, 9–12 mm. longis; antheris glabris prope basin dorsifixis, oblongo-linearibus, 10–12 mm. longis, apice obtusis; stylo perigonium aequante, stigmate ellipsoideo minute papilloso.

Type, *Killip & Hazen 9484*, collected Aug. 1 or 2, 1922, in forest below Magana, Quindio Trail, Department of Caldas, Colombia, alt. 3000–3200 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicates at B, N. Another collection from Caldas is *Killip 9809* (N, Y), from Alaska, above Salento. Two other Colombian specimens without definite locality which may be placed here are: *Linden 704* (K), *1348* (K). It is a species of the Section *Arthraxon* Eichl., allied to the Ecuadorian *P. obovatus* (Benth.) Eichl., from which it differs by having the leaves somewhat larger and more noticeably attenuate at base and the flowers twice as long.

Phthirusa tortuosa sp. nov. Frutex parasiticus glaber; ramulis teretibus elongatis subscandentibus; petiolis gracilibus rugosis superne anguste alatis 5–9 mm. longis; laminis tenuiter coriaceis ovatis vel obovatis, 4–5.5 cm. longis, 2–3.5 cm. latis, basi attenuatis, apice plerumque acutis, margine integris et cartilagineis, utrinque stomatiferis, pinnatinerviis, costa utrinque elevata, nervis secundariis 2–4-jugis adscendentibus leviter elevatis; inflorescentiis ♂ racemosis axillaribus solitariis 3–6 cm. longis; floribus sessilibus in ternationibus pedunculatis dispositis, pedunculis rugosis 1–1.5 mm. longis; bracteis deltoideis acutis, maxima circiter 1.5 mm. longa et lata; calyculo cyathiformi truncato, circiter 1 mm. longo et 1.5 mm. diametro; perigonio ad basin 6-

lobato, lobis oblongis, circiter 3.5 mm. longis et 1 mm. latis, apice obtusis, sub anthesi reflexis; staminibus alternatim circiter 2.5 mm. et 3 mm. longis; filamentis pallidis carnosis eglandulosis 1.5–2 mm. longis; antheris ovoideis, connectivis carnosis apice subacutis 0.3 mm. productis; stylo perigonium subaequante, stigmate ovoideo papilloso.

Type, *Rusby & Pennell 377*, collected July 26, 1917, on the plain between Río Cabrera and Villaviejo, Department of Huila, Colombia, alt. 500–550 meters, and deposited in the herbarium of the New York Botanical Garden. It is of the alliance of *P. orinocensis* (Spreng.) Eichl., from which species it is distinguished by its more slender habit and shorter peduncles, which are surmounted by smaller bracts.

Phthirusa gonioclada sp. nov. Frutex scandens parasiticus glaber dioecus (?); ramulis 4-angulatis vel anguste 4-alatis elongatis; petiolis rigidis rugosis 6–14 mm. longis; laminis tenuiter coriaceis vel chartaceis ovatis, 3–6 cm. longis, 1.7–2.7 cm. latis, saepe complicatis, basi acutis vel obtusis, apice acutis saepe apiculatis, margine integris cartilagineis, utrinque stomatiferis, pinnatinerviis, costa supra plana subtus prominente, nervis secundariis 3–6-jugis patulis supra planis subtus elevatis, cum venulis anastomosantibus; inflorescentiis ♂ racemosis axillaribus solitariis 5–8 cm. longis; floribus sessilibus vel subsessilibus in ternationibus pedunculatis dispositis; pedunculis rugosis 3–6 mm. longis, bracteis deciduis lanceolatis ad 4 mm. longis subtentis; bracteis ad summum pedunculorum subcoriaceis deltoideis circiter 1.5 mm. longis; calyculo cyathiformi, 1.5–1.8 mm. longo, circiter 2 mm. diametro, margine membranaceis integris; perigonio carnoso albo, ad basin 6-lobato, lobis oblongis subacutis, circiter 4.5 mm. longis, 1.2–1.5 mm. latis; staminibus alternatim circiter 3.5 mm. et 4 mm. longis; filamentis carnosis stramineis eglandulosis; antheris ovoideis, connectivis apice acutis 0.3 mm. productis; stylo carnoso, stigmate ovoideo; inflorescentiis ♀ velut ♂ sed paullo brevioribus; floribus ♀ plus minusve velut ♂, pedunculis ut videtur basi ebracteatis; calyculo sub anthesi breviter cylindrico nigrescente, circiter 2.5 mm. longo et 2 mm. diametro, limbo brevissimo erecto integro; perigonii lobis reflexis; staminibus sterilibus tenuiter carnosis, apiculis deltoideis circiter 0.5 mm. longis coronatis; stylo carnoso perigonium subaequante, stigmate globoso papilloso.

Type, *Killip & Smith 20537*, collected Mar. 12, 1927, on open hillside on the western side of Culugá Valley, north of Labateca, Department of Norte de Santander, Colombia, alt. 1480—1550 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicate at N. The type collection bears ♂ flowers. Another collection, also from Norte de Santander, which bears ♀ flowers, is: dense woods in Pica-Pica Valley, above Tapatá, north of Toledo, alt. 2100–2400 meters, *Killip & Smith 20020* (N, Y). It is a species characterized by angled branchlets, long

peduncles often subtended by bracts, and acute long-petioled leaves. Like *P. tortuosa*, it is related to *P. orinocensis* (Spreng.) Eichl. From both of these species, *P. gonioclada* is distinguished by the first two characters above mentioned and also by the larger flowers. The bracts of the ♀ inflorescence are apparently lacking, while those of the ♂ are quite prominent.

Struthanthus calophyllus sp. nov. Frutex scandens parasiticus glaber dioecus; ramulis elongatis subteretibus vel leviter angulatis lenticellosis; petiolis rugosis 4–5 mm. longis superne anguste alatis; laminis papyraceis ovatis vel ovato-oblongis, 6–10 cm. longis, 3–5 cm. latis, basi rotundatis vel obtusis, apice breviter acuminatis (apice ipso rotundatis et apiculatis), margine integris, utrinque stomatiferis, pinnatinerviis, costa supra elevata subtus prominente, nervis secundariis 4- vel 5-jugis adscendentibus, saepe e costa prope basin orientibus, utrinque elevatis, venulis utrinque conspicuis copiose reticulatis; inflorescentiis ♂ desideratis; inflorescentiis ♀ 2–4 in axillis foliorum, ternationibus pedunculatis in racemos vel pseudocymas dispositis, pedunculis circiter 3 mm. longis; floribus sessilibus vel eis lateralibus breviter pedicellatis, pedicellis ad 1 mm. longis, bracteis ovato-deltoideis circiter 0.7 mm. longis; calyculo breviter cylindrico, circiter 1.5 mm. longo et 1 mm. diametro, limbo brevissimo erecto 6-apiculato; perigonio carnoso luteo-viridi, circiter 4.5 mm. longo, 6-lobato, lobis oblongo-linearibus subacutis, 0.4–0.5 mm. latis; staminibus abortivis prope apices loborum adnatis, circiter 1 mm. longis; stylo carnoso, quam perigonio paullo breviori, stigmate subcapitato minute papilloso.

Type, *Killip & Smith 16689*, collected Jan. 5 or 6, 1927, along edge of forest in Río Suratá Valley, above Suratá, Department of Santander, Colombia, alt. 2000–2300 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicate at N. It is a species of the relationship of *S. dichotrianthus* Eichl., from which it differs by its larger papyraceous leaves, of which the venation is very prominent.

Oryctanthus lucarquensis (H.B.K.) comb. nov. *Loranthus lucarquensis* H. B. K. Nov. Gen. & Sp. **3**: 440. 1818. *Phthirusa lucarquensis* G. Don Gen. Syst. **3**: 421. 1834.

This species, known from the Province of Loja, Ecuador, falls into the Section *Cladocolea* (v. Tiegh.) Engl. of *Oryctanthus*. The section is also represented by five Central American species.[1]

Oryctanthus Archeri sp. nov. Frutex scandens parasiticus glaber; ramulis elongatis teretibus lenticellosis; petiolis rugosis canaliculatis suboppositis 7–9 mm. longis; laminis coriaceis ovato-oblongis, 5.5–7 cm. longis, 3–4 cm.

[1] Engl. & Prantl Nat. Pfl. Nachtr. **III.1**: 135. 1897.

latis, basi rotundatis, apice breviter acuminatis, margine integris, utrinque minute stomatiferis, pinnatinerviis, costa supra leviter impressa subtus prominente, nervis lateralibus 3- vel 4-jugis saepe e costa prope basin orientibus adscendentibus utrinque leviter elevatis, venulis reticulatis elevatis vel inconspicuis; inflorescentiis spicatis 2–5 in axillis foliorum 1.5–3 cm. longis 10–15-floris; floribus solitariis sessilibus, bracteis deciduis ovatis ad 2.5 mm. longis subtentis; calyculo breviter cylindrico vel cyathiformi, sub anthesi circiter 1.5 mm. longo et lato, limbo brevi erecto membranaceo subintegro vel minute 4-apiculato; perigonio carnoso ad basin 4-lobato, lobis ovato-oblongis, circiter 2.8 mm. longis et 1.3 mm. latis, basi contractis, apice acutis; staminibus quam perigonio paullo brevioribus; filamentis lobis adnatis; antheris sessilibus deltoideo-ovoideis, 0.8 mm. longis, basi subcordatis, apice subacutis; stylo carnoso circiter 2 mm. longo, stigmate subtruncato; baccis ovoideis vel obovoideis ad 6 mm. longis, apice truncatis.

Type, *W. A. Archer 1521*, collected Jan., 1931, at La Sierra, 18 kilometers north of Medellín, Department of Antioquia, Colombia, alt. about 2000 meters, and deposited in the U.S. National Herbarium (no. 1,517,470). The collector notes that the flowers are dull yellow-green, the fruit rose-red when young, becoming blue with a grayish bloom. It is a species of the Section *Cladocolea* (v. Tiegh.) Engl., related to *O. lucarquensis* (H. B. K.) A. C. Smith, from which it differs by its larger leaves and longer spikes, which are aggregated rather than solitary. These two species, with solitary sessile tetramerous flowers subtended by single bracts, are readily distinguished from others of the family in South America.

Monimiaceae

Siparuna Archeri sp. nov. Frutex 2–4 m. altus; ramulis divaricatis subteretibus fuscescentibus minute stellulato-pilosis; petiolis subteretibus parce pilosis 4–7 mm. longis; laminis viridibus elliptico-oblongis, 15–20 cm. longis, 4.5–7 cm. latis, basi cuneatis vel acutis, apice acuminatis, margine subintegris, utrinque parce praecipue nervis pilos stellatos minimos gerentibus, pinnatinerviis, nervis lateralibus 12–15-jugis arcuato-adscendentibus prope marginem subanastomosantibus, cum costa supra elevatis subtus prominentibus, venulis copiose reticulatis utrinque elevatis; inflorescentia axillari cymosa brevi 3–7-flora; pedunculo 5–7 mm. longo, cum floribus plus minusve dense fusco-stellulato-piloso; pedicellis 1–3 mm. longis; floribus ♂ circiter 1.5 mm. diametro; tepalis erectis oblongis rotundatis incurvatis 0.8–1 mm. longis et latis, extra pilosis intus glabris; velo tenuiter carnoso angusto plano circiter 0.3 mm. lato; staminibus 10–12, exterioribus majoribus et exsertis, pallidis glabris tenuiter carnosis oblongis subacutis, maximis 0.8 mm. longis et 0.3 mm. latis; antheris filamenta aequantibus, poris ovalibus contiguis circiter 0.25 mm. longis; floribus ♀ sub anthesi quam ♂ paullo majoribus; tepalis eis ♂ similibus; velo conico-elevato 0.5 mm. longo, ore 0.2 mm. diametro; stylis 6–8

liberis recurvatis circiter 0.6 mm. exsertis; drupis coriaceis rugosissimis subglobosis circiter 1 cm. diametro.

Type, *W. A. Archer 1840*, collected in April or May, 1931, near Quibdó, on Río Atrato, Intendencia of Chocó, Colombia, alt. about 60 meters, and deposited in the U. S. National Herbarium (no. 1,518,730). The collector notes that the fruit is cream-colored tinged with red, has a strong lemon odor, and when ripe dehisces violently and irregularly. It is a species not closely related to any known from Colombia, but allied to the Central American *S. nicaraguensis* Hemsl., than which it has proportionately narrower leaves with shorter petioles. The present species has smaller flowers than *S. nicaraguensis*, the tepals more erect and more deeply distinct from one another, and the stamens nearly twice as many. From *S. macrotepala* Perk., a Peruvian ally, the new species differs by its more numerous lateral nerves, longer petioles, smaller tepals, etc.

SIPARUNA VENEZUELENSIS Perk. This species, previously known from *Fendler 2358* (type coll., a sheet of which is at K), from Colonia Tovar, State of Aragua, Venezuela, proves to be fairly common in the Eastern Cordillera of Colombia. Here it grows in dense wet woods of the temperate zone, at altitudes of 2000–3000 meters, becoming a slender shrub up to 6 or 7 meters in height. It is represented by the following *Killip & Smith* collections: Santander: Río Suratá Valley, above Suratá, *21161* (N, Y); Western slope of Mt. San Vicente, near Charta, *18972* (N, Y); Southern slope of Mt. San Martín, near Charta, *19150* (N, Y), *19177* (N, Y); Las Vegas, *16039* (N, Y). On these specimens the ♀ flowers are somewhat more mature than those of the type collection, demonstrating the enlargement of tepals after anthesis to a size of 3 mm. by 1.5 mm.

Siparuna sinuata sp. nov. Frutex vel arbor parva; ramulis teretibus fuscis glabris; petiolis rugosis oppositis vel suboppositis 7–14 mm. longis, superne anguste alatis, alis parce pilosis; laminis chartaceis oblongis vel obovato-oblongis, 7–10 cm. longis, 3–4 cm. latis, basi truncatis vel obtusis, apice breviter acuminatis, apice ipso obtusis, margine irregulariter sinuato-crenulatis, utrinque glabris, pinnatinerviis, nervis lateralibus 7- vel 8-jugis arcuato-adscendentibus prope marginem subevanescentibus, cum costa utrinque planis vel leviter elevatis, venulis paucis planis; inflorescentiis ♂ in foliorum axillis plerumque binis, maturitate 2–3 cm. longis 10–20-floris, glabris vel parcissime cinereo-pilosis; pedicellis 1–4 mm. longis; floribus ♂ nigrescentibus subcoriaceis maturitate 4–5 mm. diametro, parce minute luteo-glandulosis; receptaculis obconico-subglobosis supra medium limbo angusto 0.5 mm. lato obtuse 6-gono (e tepalis connatis saepe parce setosis constante) circumdatis; velo conico-elevato circiter 1.8 mm. longo, ore maturitate circiter 1.5 mm. diametro; staminibus circiter 6 nigrescentibus, margine membranaceis, dor-

saliter parce glandulosis, oblongis, circiter 3 mm. longis, ad 1.8 mm. latis, apice subacutis; filamentis quam loculis triplo longioribus; poris ovalibus contiguis circiter 0.5 mm. longis; inflorescentiis ♀ et drupis desideratis.

Type, *R. A. Toro 1346*, collected Sept. 10, 1928, at San Roque, near Medellín, Department of Antioquia, Colombia, and deposited in the herbarium of the New York Botanical Garden. It is a species related to *S. venezuelensis* Perk., from which it differs by having the leaves rounded rather than acute at base, the margins sinuate rather than denticulate, the inflorescence longer and the tepals more reduced.

SIPARUNA PENNELLII Perk. Colombia: Antioquia: Valparaiso, near Medellin, *Toro 1378* (Y). Previously known from the Departments of Caldas and El Valle. Our specimen, the precise vegetative equal of earlier collections, is apparently the first collection of ♂ inflorescence, which is here described:

♂ inflorescences usually 2 in leaf axils, subglabrous (deciduously stellulate-pilose), 10–20 mm. long, 6–12-flowered; pedicels 1–3 mm. long; mature flowers about 3.5 mm. in diameter; tepals 6 (rarely 5), minute, fused into a narrow ridge about 0.4 mm. broad; receptacle obconical-subglobose, densely pale yellow-glandular within; velum conical-elevated, membranous, about 1.3 mm. long, the aperture 1–1.3 mm. in diameter; stamens about 7, at maturity exserted, densely pale yellow-glandular on both surfaces (glands sessile, 0.1 mm. in diameter), oblong or ovate, obtuse at apex, 2.5–2.8 mm. long, 1.5–2.3 mm. broad; filaments 2 or 3 times as long as anthers, membranous; pores oval, 0.5 mm. long, the valves contiguous in dehiscence.

Siparuna tapatana sp. nov. Frutex 3–5 m. altus; ramis elongatis gracilibus divaricatis; ramulis teretibus fuscis minute cinereo-stellulato-pilosis; petiolis oppositis vel suboppositis teretibus 7–15 mm. longis velut ramulis novellis pilosis; laminis papyraceis oblongis vel elliptico-oblongis, 12–15 cm. longis, 5–7 cm. latis, basi obtusis vel anguste subcordatis, apice acuminatis, margine irregulariter serratis (dentibus minute callosis 5 vel 6 per centimetrum), utrinque subglabris vel parce stellulato-pilosis, stellis secus nervos principales densioribus, pinnatinerviis, nervis lateralibus circiter 10-jugis patulis prope marginem adscendentibus et irregulariter anastomosantibus, cum costa supra planis subtus prominentibus, venulis reticulatis saepe supra occultis; inflorescentiis ♂ cymosis, cymis in foliorum axillis 1–3 paucifloris 10–15 mm. longis, juventute ubique dense fusco-stellulato-pilosis; pedicellis 4–6 mm. longis; floribus ♂ maturitate subglabris 2–3 mm. diametro; receptaculis obconico-subglobosis superne limbo angusto 0.5 mm. lato obtuse 5- vel 6-gono (e tepalis connatis constante) circumdatis; velo molliter carnoso glabro conico-elevato circiter 1.3 mm. longo, ore minuto circiter 0.4 mm. diametro; staminibus circiter 6 carnosis glabris eglandulosis oblongo-ovatis, circiter 2.5 mm. longis, 0.8–1.5 mm. latis, apice contractis sed obtusis; filamentis quam an-

theris duplo longioribus; antheris per poros ovales contiguos circiter 0.7 mm. longos dehiscentibus; floribus ♀ sub anthesi quam ♂ majoribus; pedicellis ad 12 mm. longis; tepalis quam eis ♂ majoribus carnosis deltoideis, circiter 0.8 mm. longis, 1–2 mm. latis; velo conico-elevato maturitate 0.5 mm. longo, ore circiter 0.4 mm. diametro; stylis 5–7 praeter apicem subcohaerentibus, circiter 1 mm. exsertis; drupis juvenilibus subglobosis glabris 5 mm. diametro.

Type, *Killip & Smith 20330*, collected Mar. 5 or 6, 1927, in woods on the western side of Culugá Valley, above Tapatá, north of Toledo, Department of Norte de Santander, Colombia, alt. about 2300 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicate at N. Another collection, also from Norte de Santander, is: Woods along stream near Loso, north of Toledo, 2200–2400 m., *Killip & Smith 20399* (N, Y). The type collection bears ♂ flowers, the other here cited bears ♀. It is a species related to *S. Pennellii* Perk., from which it differs by having the leaves thinner in texture and more closely and conspicuously serrate and the young parts more noticeably pilose. In structure of the ♂ flowers the two species are closely allied; however, in *S. tapatana* the stamens are carnose and eglandular, while in *S. Pennellii* they are membranous and densely glandular. The ♀ flowers of the new species are more persistently pubescent than those of *S. Pennellii*.

Siparuna asterotricha sp. nov. Frutex; ramulis crassis rectis teretibus, pilis stramineis stellatis subtomentosis dense indutis (pilorum ramulis ad 0.5 mm. longis); petiolis suboppositis teretibus velut ramulis densissime tomentosis 7–12 mm. longis; laminis oblongis vel elliptico-oblongis, 11–13 cm. longis, 4–5.5 cm. latis, basi rotundatis vel obtusis, apice breviter caudato-acuminatis, margine sinuato-serratis (dentibus callosis 4–6 per centimetrum), utrinque praecipue nervis pilos stellatos 10–15-ramosos gerentibus, pilis supra circiter 0.4 mm. diametro et 4–7 per millimetrum quadratum, pilis subtus circiter 0.7 mm. diametro et 2–4 per millimetrum quadratum, pinnatinerviis, costa supra elevata subtus prominente, nervis lateralibus plerumque 10-jugis arcuato-adscendentibus, prope marginem subanastomosantibus, supra planis subtus elevatis, venulis obscure reticulatis; inflorescentiis axillaribus subspicatis solitariis vel binis 10–20-floris, partibus exterioribus pilis minutis dense stellato-tomentosis; pedunculo 2–3.5 cm. longo; pedicellis 3–6 mm. longis; floribus ♂ sub anthesi 4–7 mm. diametro; receptaculo obconico circiter 2 mm. longo et 3 mm. diametro; tepalis nigrescentibus patulis oblongis, circiter 2 mm. longis et latis, apice rotundatis, intus glabris; velo breviter cylindrico, circiter 1 mm. longo, margine integro et membranaceo; staminibus subcoriaceis 10–12 oblongis, exterioribus et maximis circiter 2.5 mm. longis et 1.5 mm. latis, per poros contiguos circiter 0.6 mm. diametro dehiscentibus; floribus ♀ desideratis; drupis coriaceis longipedicellatis subglobosis circiter 15 mm. diametro.

Type, *R. A. Toro 966*, collected Feb. 1, 1928, at Tamesis, near Medellín, Department of Antioquia, Colombia, and deposited in the herbarium of New York Botanical Garden. It is a very distinct species, characterized by the small leaf hairs, the size and distribution of which are remarkably uniform. From *S. Trianae* A. DC., probably its nearest ally, it is distinguished by the pubescence, the larger leaves, the longer inflorescence, and the larger tepals. The single fruit on the type specimen is found on an inflorescence which also bears ♂ flowers; ♀ flowers are lacking.

Siparuna elliptica sp. nov. Frutex; ramulis fuscis angulatis vel subteretibus, juventute pilis stellatis cinereis 1–2 mm. longis indutis, demum glabrescentibus; petiolis oppositis rugosis subteretibus velut ramulis juvenilibus pilosis 1.5–4 cm. longis; laminis papyraceis elliptico-oblongis 20–25 cm. longis, 13–16 cm. latis, basi rotundatis, apice rotundatis vel obtusis, margine sinuato-serratis (dentibus callosis 3–5 per centimetrum), supra praecipue nervis pilis simplicibus indutis demum glabrescentibus, subtus pilos stellatos ad 1 mm. latos gerentibus, pinnatinerviis, costa crassa utrinque prominente, nervis lateralibus 15–18-jugis rectis patulis prope marginem adscendentibus utrinque leviter elevatis, venulis copiose anastomosantibus utrinque leviter elevatis vel planis; inflorescentiis ♂ axillaribus solitariis vel binis cymosis ad 4 cm. longis 8–15-floris; pedunculo rugoso 1.5–2.5 cm. longo, pilis simplicibus vel stellatis piloso, pedunculorum ramulis apice 3- vel 4-floris; pedicellis 3–6 mm. longis; receptaculo obconico sub anthesi circiter 5 mm. longo et 4 mm. diametro, velut pedunculo molliter piloso; tepalis 5 carnosis nigrescentibus oblongis patulis, 4–5 mm. longis, 1.5–2 mm. latis, apice subacutis et minute calloso-mucronatis, maturitate utrinque glabris; velo membranaceo elevato-conico, circiter 2 mm. diametro, ore parvo; staminibus 7 vel 8 dorsaliter parce glandulosis oblongis vel ovatis, circiter 3 mm. longis, exterioribus ad 3 mm. latis, margine membranaceis, apice obtusis, per poros contiguos ad 1 mm. longos dehiscentibus; inflorescentiis ♀ et drupis desideratis.

Type, *R. A. Toro 401*, collected Aug. 20, 1927, at Titiribi, near Medellín, Department of Antioquia, Colombia, and deposited in the herbarium of the New York Botanical Garden. Doubtless larger leaves than those above described will be found on more mature specimens. It is a species related to *S. amplifolia* A. DC., from which it differs by having the pubescence less dense throughout, the tepals 5 rather than 3 or 4, and the receptacle soft pilose rather than densely hispid.

Siparuna huilensis sp. nov. Frutex dioecus; ramulis elongatis teretibus, pilis ferrugineis stellato-tomentosis deciduis ad 0.8 mm. longis ac etiam pilis brevioribus puberulis persistentibus indutis; petiolis plerumque ternatis subteretibus velut ramulis pubescentibus 10–20 mm. longis (raro 25 mm.); laminis chartaceis (senioribus coriaceis et bullatis) oblongis vel obovato-oblongis, 12–17 cm. longis, 5.5–7.5 cm. latis, apice subacutis vel breviter acumi-

natis, basi cuneatis (basi vera anguste truncatis vel subcordatis), margine subintegris vel crenato-serratis (dentibus 2–5 per centimetrum) saepe anguste revolutis, utrinque pilos stellatos 0.3–0.4 mm. diametro gerentibus, pinnatinerviis, nervis secundariis 9–11-jugis arcuato-adscendentibus, cum costa supra planis vel impressis subtus prominentibus, venulis reticulatis supra saepe impressis subtus leviter elevatis; inflorescentiis ♂ desideratis; inflorescentiis ♀ cymosis plerumque 2 vel 3 in axillis foliorum 5–10-floris; pedunculo gracili 1–3 cm. longo fusco-stellato-puberulo; pedicellis sub anthesi 3–5 mm. longis; floribus ♀ extus velut pedunculo puberulis demum glabrescentibus, receptaculo obconico sub anthesi circiter 2 mm. longo et 3 mm. diametro; tepalis 5 (raro 6) intus glabris patulis ovatis subacutis calloso-mucronatis, 1.5–2.5 mm. longis, 1.7–2 mm. latis; velo elevato-conico molliter carnoso glabro 1–1.5 mm. longo, ore circiter 0.4 mm. diametro; stylis circiter 8 nigrescentibus leviter cohaerentibus, circiter 1 mm. exsertis apice divaricatis; drupis coriaceis subglobosis ad 12 mm. diametro, pedicellis ad 20 mm. longis.

Type, *Rusby & Pennell 869*, collected Aug. 1–8, 1917, in forest east of Neiva, Department of Huila, Colombia, alt. 1800–2300 meters, and deposited in the herbarium of the New York Botanical Garden. Other collections from the same locality are: *Rusby & Pennell 583* (Y), *870* (Y). All three of these specimens are ♀; the latter bears somewhat smaller leaves than the type but is similar in other respects. The collectors note that the plant is aromatic and the tepals greenish-white. It is a species related to *S. Mutisii* (H.B.K.) A. DC., from which it differs by having its leaves larger, more persistently pilose, and with more numerous secondary nerves. The ♀ flowers of the new species have the velum conical rather than plane.

Siparuna pectinata sp. nov. Frutex dioecus 2–4 m. altus; ramulis paucis rectis divaricatis teretibus, pilis ferrugineis stellato-tomentosis circiter 0.5 mm. longis dense indutis; petiolis suboppositis subteretibus velut ramulis tomentosis 6–16 mm. longis; laminis oblongis, 8–15 cm. longis, 4.5–7 cm. latis, basi rotundatis vel subcuneatis, apice subacutis, margine prominenter crenato-serratis (dentibus irregularibus 3–7 per centimetrum, versus basin et summo petioli elongatis), utrinque praecipue nervis pilos stellatos 4–9-ramosos gerentibus, pilis supra circiter 0.8 mm. diametro et 2–4 per millimetrum quadratum, pilis subtus paullo majoribus, pinnatinerviis, costa supra leviter elevata subtus prominente, nervis lateralibus plerumque 9-jugis arcuato-adscendentibus supra planis subtus elevatis, venulis inconspicue reticulatis; inflorescentiis ♂ cymosis plerumque 2 vel 3 in axillis foliorum 8–15-floris (floribus mox deciduis), ubique partibus exterioribus pilis ferrugineis circiter 0.3 mm. longis dense et arcte stellato-tomentosis; pedunculo 4–10 mm. longo; pedicellis gracilibus 2–3 mm. longis; floribus ♂ sub anthesi circiter 3.5 mm. diametro, receptaculo 1–1.5 mm. longo; tepalis 5 vel 6 patulis deltoideis acutis basi connatis, 1–1.3 mm. longis, 1.5–2 mm. latis; velo plano intus glabro 1.3–1.5 mm. diametro, ore circiter 0.4 mm. diametro; staminibus 6–8, antheris sessilibus oblongis

circiter 1 mm. longis et latis, apice rotundatis vel obtusis, squamas castaneas minutas dorsaliter gerentibus, per poros circiter 0.3 mm. diametro dehiscentibus; inflorescentiis ♀ axillaribus brevibus plerumque solitariis 3–5-floris, velut ♂ tomentosis; floribus ♀ quam eis ♂ majoribus, sub anthesi 5–7 mm. diametro, receptaculo obconico circiter 2.5 mm. longo et diametro; tepalis 6 vel 7 patulis ovatis subacutis circiter 2 mm. longis et latis; velo molliter carnoso plano circiter 3 mm. diametro, ore minuto; stylis circiter 12 nigrescentibus erectis leviter cohaerentibus circiter 0.7 mm. exsertis.

Type, *Killip & Smith 21135*, collected Dec. 11–15, 1926, in woods on the northern slope of Mesa de los Santos, above Piedecuesta, Department of Santander, Colombia, alt. 1000–1500 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicate at N. Another collection from the same locality is *Killip & Smith 15056* (N, Y). Description of ♂ flowers is from the type collection, of ♀ flowers from no. *15056*. Leaves of the ♀ plant appear to be slightly larger and more acute at base than those of the ♂ plant. It is a species readily distinguished by the exaggerated serrations at the base of the leaves, which are given a ragged appearance. The unusually close tomentum is also characteristic. It is not closely related to any Colombian species, but may be allied to the Central American *S. tetraceroides* Perk., from which, in addition to foliage characters, it differs by having the upper surface of tepals and velum densely tomentose rather than glabrous.

Siparuna subscandens sp. nov. Frutex subscandens 6–10 m. altus; ramulis elongatis teretibus, juventute pilis densis ferrugineis stellatis ad 0.3 mm. longis indutis, demum glabrescentibus; petiolis oppositis vel suboppositis canaliculatis dense et arcte ferrugineo-tomentosis 8–18 mm. longis; laminis elliptico-oblongis maturitate coriaceis, 8–16 cm. longis, 3.5–7 cm. latis, basi acutis vel subacutis, apice breviter acuminatis, margine crenatis (dentibus minute apiculatis 4 vel 5 per centimetrum), utrinque pilis stellatis circiter 0.3 mm. diametro ferrugineo-tomentosis, pinnatinerviis, nervis lateralibus 8–10-jugis rectis adscendentibus, cum costa supra subplanis subtus prominentibus, venulis reticulatis supra planis subtus elevatis; inflorescentiis ♂ axillaribus plerumque binis 6–12-floris; pedunculo 7–15 mm. longo velut ramulis ferrugineo-tomentoso; pedicellis crassis 2–5 mm. longis; floribus ♂ extra dense tomentosis, receptaculo campanulato sub anthesi 1.5–2.5 mm. longo et 2.5–3 mm. diametro; tepalis 5 aequalibus erectis oblongis, 0.6–0.8 mm. longis, 1–1.5 mm. latis, apice rotundatis et apiculatis, intus glabris; velo plano molliter carnoso nigrescente glabro 1.8–2.5 mm. diametro, ore sub anthesi 0.5 mm. diametro; staminibus circiter 15 molliter carnosis fusco-castaneis luteo-glandulosis ovato-deltoideis, exterioribus et maximis 1.3–1.5 mm. longis et basi latis, apice acutis, per poros contiguos circiter 0.7 mm. longos dehiscentibus; inflorescentiis ♀ et drupis desideratis.

Type, *W. A. Archer 1361*, collected at La Sierra, 18 kilometers north of Medellín, Department of Antioquia, Colombia, alt. about 2000 meters, and deposited in the herbarium of the New York Botanical Garden. Duplicate at N. It is a species related to *S. asperula* (Tul.) A. DC., which it closely resembles in foliage. However, the new species apparently never has the leaves ternate. From *S. asperula* it also differs by having the inflorescence longer, the velum of ♂ flowers glabrous, and the stamens twice as numerous.

Siparuna quadrangularis sp. nov. Frutex 1–2 m. altus; ramulis crassis quadrangulatis subnigrescentibus cinereo-stellato-pilosis (stellis ad 1 mm. latis); petiolis oppositis crassis angulatis vel subteretibus velut ramulis pilosis 2.5–5 cm. longis; laminis oblongis, 25–35 cm. longis, 16–20 cm. latis, basi rotundatis, apice (?, specimino nostro incompleto), margine irregulariter serratis (dentibus 3–5 per centimetrum), supra parce (nervis dense) stellato-pilosis, subtus pilis stellatis densis cinereis villosis indutis, pinnatinerviis, costa crassa supra elevata subtus prominentissima, nervis lateralibus 15–20-jugis patulis rectis supra planis vel elevatis subtus prominentibus, venulis copiose reticulatis supra planis subtus elevatis; inflorescentia ♂ desiderata; inflorescentia ♀ axillari brevi 2–5-flora; pedicellis 2–4 mm. longis; floribus ♀ ad summum tubi sub anthesi 2–2.5 mm. diametro, tubo cum pedicello dense stellato-piloso, stellis ad 0.5 mm. longis; tepalis 4 carnosis late ovatis, 3–4 mm. longis et latis, apice apiculatis, extra et margine parce pilosis intus glabris; velo carnoso glabro conico-elevato circiter 0.8 mm. longo, ore circiter 0.6 mm. diametro; stylis 10–12 liberis recurvatis circiter 1.3 mm. exsertis.

Type, *Hitchcock 21317*, collected Sept. 2, 1923, between Portovelo (Gold Mine near Zaruma) and El Tambo, Province of Oro, Ecuador, alt. 600–1000 meters, and deposited in the herbarium of the New York Botanical Garden. It is a species related to *S. eriocalyx* (Tul.) A. DC., and *S. gesnerioides* (H.B.K.) A. DC., from both of which it differs by having its branchlets quadrangular and its tepals apparently always 4 rather than 4 to 6. Compared with *S. eriocalyx*, the new species has the leaves larger and the tepals glabrous within; compared with *S. gesnerioides*, it has the inflorescence shorter and the styles about twice as many.

THE NEW YORK BOTANICAL GARDEN

Cultural races and the production of variants in *Pestalozzia funerea*[1]

CLYDE CHRISTENSEN[2]

(WITH SIX TEXT FIGURES)

INTRODUCTION

In 1929, in the course of a study of a leaf disease of longleaf pine (*Pinus palustris* Mill.), the writer frequently found *Pestalozzia funerea* Desm. growing saprophytically on those portions of the leaves which had been killed by *Septoria acicola* (Thüm). A large number of single spores of *P. funerea* were isolated, and it soon became evident that the species comprises many different cultural races. Not only were a considerable number of races isolated, but variants appeared frequently in some of the cultures. As the material seemed very interesting from a mycological viewpoint, a study was made of the different races and their tendency to produce variants.

MATERIAL AND METHODS

Cultures were made by cutting out small sections of the needles, surface sterilizing the sections, and placing them on malt agar in petri dishes. The fungus grew rapidly on the agar and within a week it produced an abundance of acervuli on the surface of the cultures. One hundred and fifty single spores were isolated, 125 from the acervuli on the needles of longleaf pine and 25 from acervuli produced in the cultures described above, most of them by the plate dilution method. The cultures derived from these were grown on agar slants in test tubes, and those which appeared to be different from each other were transferred in duplicate to malt agar in 200 cc. Erlenmeyer flasks, each containing 32 cc. of agar. When these flask cultures were compared with one another, striking differences were observed in rate of growth, appearance of mycelium, and production of spores.

In the 150 cultures, derived from single spores, fifteen different races were found, each of which could be distinguished from every other one by rate of growth, color and topography of the surface mycelium, the abundance, manner, and time of spore production, and color and morphology of spores.

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[2] The writer wishes to express his indebtedness to Dr. E. C. Stakman, under whose direction this work was done.

To facilitate a comparative study, all of the parent cultures, obtained in the manner described above, and the sectors which appeared in these cultures, were transferred in duplicate to Coon's, Richard's, and malt agar in 200 cc. Erlenmeyer flasks.

GROWTH CHARACTERS

In the cultures obtained from the pine needles at least a dozen very distinct races could be distinguished solely by their growth characters. To illustrate the differences between some of the races, several of them will be described as they appeared on malt agar, when the cultures were twelve days old.

Race 4: Mycelium in a dense flat mat; no aerial mycelium; three prominent concentric zones present, the outer one $\frac{1}{4}$ inch wide and white, the second one $\frac{1}{2}$ inch wide and pale yellowish brown, and in the center a lighter colored disc $\frac{1}{4}$ inch in diameter. No spores produced.

Race 6: Mycelium in a dense flat mat as in 4, but more scanty; uniformly yellowish brown, with a darker concentric band faintly visible in the center. Same rate of growth as 4. No spores produced.

Race 5: Mycelium white, abundant, appressed. Acervuli abundant in four broad concentric bands; acervuli very small, running together to form black, shiny, moist patches.

Race 18: Mycelium closely packed, grayish, aerial mycelium united into netlike tufts. Acervuli numerous, varying in size, evenly distributed.

Race 25: Mycelium with a pinkish tint, closely packed in a thick layer on the surface of the agar. Aerial mycelium united into tiny netlike tufts.

The above descriptions illustrate the method used in differentiating the races, but they hardly give an adequate conception of the degree of diversity of races on artificial media. Some of the races grew as much in three days as others did in three weeks; in some the mycelium was appressed, in others densely flocculent, in others woven into netlike tufts; in some the color was very white, in others a dirty grayish green, faint yellow, or delicate pink; in some races the growth was marked with rings, in others it was uniform throughout; some produced only a few spores, while in others the cultures were black with spores.

These races have been grown for more than a year on artificial media and few of them have shown any noticeable tendency to vary in a permanent way, except where sectors appeared. Their growth was different under different conditions, and on different media, but always, when returned to the medium upon which they were first grown, they displayed the characteristics of the original cultures. Six of the races are shown in figure 1.

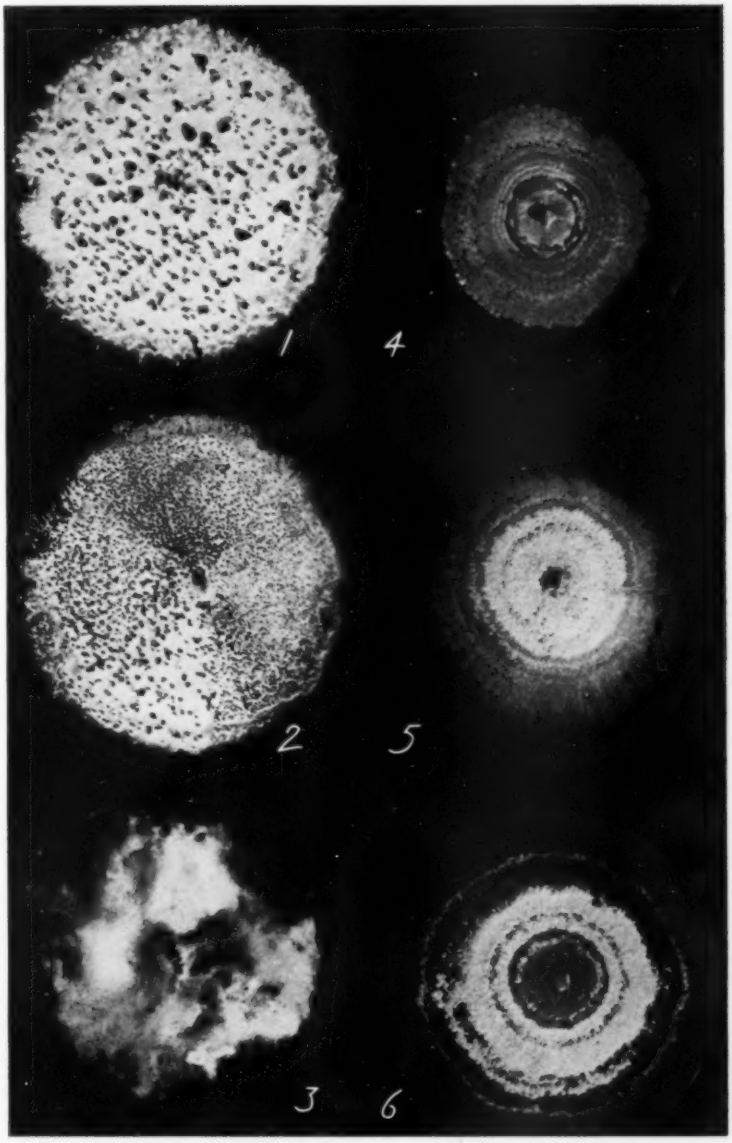

Fig. 1. Six races of *Pestalozzia funerea* isolated from pine needles. Cultures grown under similar conditions. *1*, race 8; *2*, race 2; *3*, race 7; *4*, race 3; *5*, race 6; *6*, race 4.

Spore production

In the comparative study of these races on the three different media, the number of days elapsing from the time of inoculation of the flasks to the appearance of acervuli in each culture was recorded. While it is recognized that this is a character which apparently may vary somewhat with slight changes in environment, yet in a strictly comparative study, carried out under conditions which permitted only very small differences in environment between any two cultures, great differences in the time, manner, and abundance of spore production may be assumed to carry some weight in the differentiation of races, especially when coupled with other characteristics.

Wenner (1914), working with *Pestalozzia funerea*, found that his original cultures formed conidia in ten to fifteen days after inoculation, while his later cultures, which were subcultures of the original ones, formed conidia in three days. He said that possibly the fungus had become better adapted to the medium. The evidence which has been collected against the theory of such rapid adaptation of fungi would make it seem possible that the phenomenon might be explained more plausibly in either of the following ways: Either he gradually and unconsciously changed the medium to suit the conditions necessary for the production of spores, which is unlikely, or, which seems more probable, he had a mixed culture of several races and gradually selected those which produced conidia in a short time. It is possible, too, that variants may have arisen which produced spores in a shorter time than the parent cultures. In the races studied by the writer great differences were found in the time required to form spores. One race produced an abundance of spores in three days, another required thirty days to produce spores, and some did not produce any at all. (See table 1). Repeated experiments have proved this to be a constant character.

Not only was there considerable difference in the time required to produce spores but there was also an appreciable difference in the abundance of acervuli produced, and in their size and position on the culture. For example, cultures of race 25 always produced an abundance of acervuli distributed over the surface of the culture in several broad, black bands, while in cultures of race 26 they were produced in fewer numbers and were distributed evenly over the surface. In cultures of race 18 they were produced in great abundance, evenly distributed over the surface, appearing as tiny, slightly protruding pimples, while in cultures of race 17 they were very sparsely produced, and appeared in isolated groups; they looked like specks of dust on the surface, so small that they were barely perceptible.

A biometrical study was made to determine whether there were significant differences in the size of spores of the different races, using only those races in which it was thought, from general observation, that differences might be present. The technique of obtaining a random sample was as follows: An inoculating needle was drawn across a culture several times, and the spores so obtained were placed in a test tube containing about 5 cc. of distilled water. The tube was thoroughly shaken and several drops of the spore suspension were placed on a slide. One hundred spores from each race were measured. The results are given in table 2. It is apparent that no important difference was found in the length of spores and length of median cells between any two of the races studied, but there is a distinct

TABLE 1

Number of days from inoculation to production of acervuli in seven races of Pestalozzia funerea grown in duplicate on three different agar media at room temperature.

RACE	MEDIUM					
	MALT		RICHARD'S		COON'S	
	FLASK		FLASK		FLASK	
	1	2	1	2	1	2
1	18	18	13	10	18	18
3	—	—	—	—	—	—[1]
5	3	3	3	3	3	3
24	30	33	18	24	17	17
10	13	13	17	17	12	12
8	8	8	6	6	6	6
21	4	4	4	4	4	4

[1] No acervuli formed.

difference in length of setae. In race 2–1 the setae averaged 15.63 microns in length, while in race 10–2 they averaged 33.93 microns, or more than twice as long. This difference is large enough and constant enough to separate these two forms rather sharply. The other forms were intermediate between these two.

Guba (1929) has made a key for a part of the genus *Pestalozzia*, in which he separates the different species largely upon the basis of spore measurements, the length of median cells of *P. funerea* being from 15 to 18 microns. Two of the races studied by the writer fell below the lower limit, and the other two were just above it. Guba gives the upper limit of length of setae in *P. funerea* as 20 microns, but the foregoing analysis shows that some may exceed this limit by more than ten microns. These apparent discrepancies between Guba's results and the writer's may be

due to the fact that the spores measured by Guba were obtained from plant tissues, while those measured by the writer were from cultures on an artificial medium, although it is possible that some of the races investigated by the writer were genotypically different from those with which Guba worked. Or, it may be a combination of both heredity and environment. Whatever the true explanation may be, it would seem desirable to widen the limits of the species somewhat.

It is not the aim of the writer to set up a criterion whereby the different races of this fungus might be differentiated from one another on the basis of morphological differences in the spores; even if that could be done, it would be of little advantage. It is desired to show merely that there are

TABLE 2

Comparison of length of spores, length of three median cells, and length of setae of different races of Pestalozzia funerea.

Race	17–1	21	10–2		
Length of spores	23.768	22.248	22.851		
Probable error	0.125	0.105	0.111		
Race	17–1	10–2	12	2–1	
Length of median cells	15.069	15.276	14.409	14.313	
Probable error	0.073	0.060	0.067	0.060	
Race	21	10–2	12	2–1	5
Length of setae	18.42	33.93	16.53	15.63	24.96
Probable error	0.206	.391	0.379	0.233	0.305

perceptible differences between the spores produced by the different races when grown under similar conditions. The data are given as added proof of the existence of distinct races within the species.

Coloring of the median cells also has been considered an aid in separating species of *Pestalozzia*. In the different races studied by the writer the cell coloring varied sufficiently to serve as a distinguishing characteristic of certain races. For example, numbering the three colored cells consecutively from the end which bears the stalk toward the end which bears the setae, the following differences were observed. In the spores of race 21 the first colored cell was light brown, and the second and third were very dark brown. In the spores of race 2 the first colored cell was almost transparent and the other two were very light brown, being about the same color as the first cell in the spores of race 21. In the spores of race 12 the first colored cell was almost transparent, the second was dark, and the third was slightly lighter than the second. Races 21 and 2 could be separated from each other and all others on this basis, and race 12 could be separated from

some of the other races, but not from all, on the same basis. These differences within one species make it seem likely that coloring of the median cells may not always be a very reliable character for delimiting species.

These dissimilarities in the spores were not dependent upon the age of the cultures. In so far as the writer has been able to determine by general observation and biometrical study, there is no perceptible variation in the

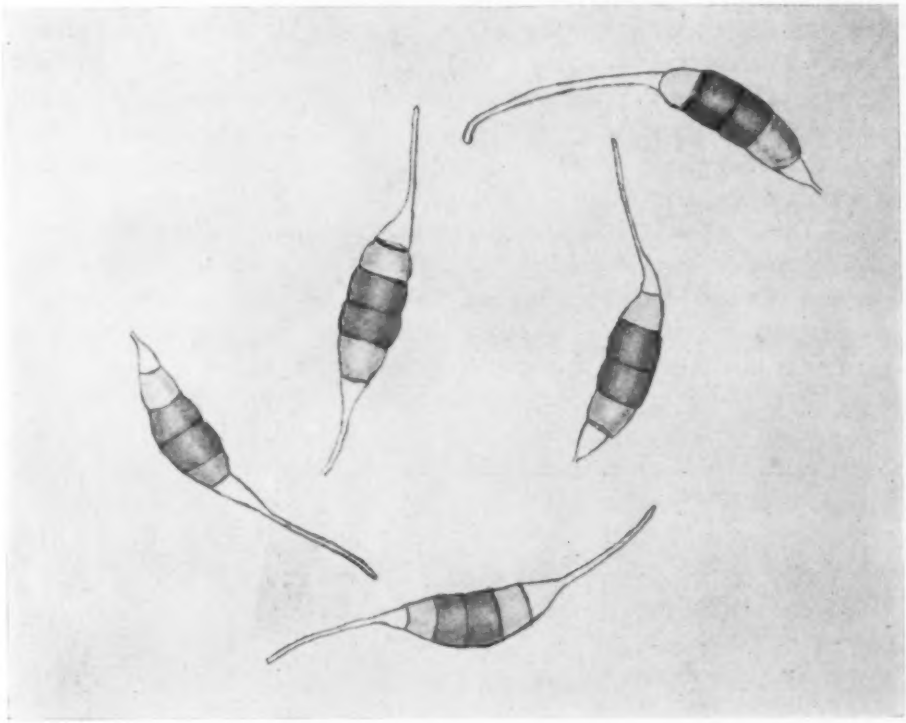

Fig. 2. Spores of race 4. Each spore has only one seta. Drawn with the aid of a camera lucida.

size, shape, or color of the spores, length of setae, or length of basal appendage with increasing age of the culture. This confirms the observations of LaRue (1922) in his biometric study of *P. Guepini*, where he found that there was no measurable difference between the spores produced early in the life of the culture and those produced later.

With two exceptions, in every race of *P. funerea* in which spores were produced the spores were five-celled. Race 4, which did not produce spores on ordinary media, was grown on tube slants of malt agar to which had been added several pieces of longleaf pine needles, after the medium was

tubed but before it was sterilized. In this medium the fungus grew more rapidly than on the malt agar alone, and after two weeks it produced several acervuli. The spores had only one seta. Several of these spores were drawn with the aid of a camera lucida and are shown in figure 2. Race 3, which resembled race 4 somewhat in cultural characters, and, like it, did not produce spores on standard media, produced spores on malt agar to which had been added a trace of benzaldehyde, and it produced a few acervuli on malt agar to which had been added a trace of ethylene chlorhydrin. These spores were nearly hyaline, and, like those produced by race 4, had only one seta. Race 6 resembled races 3 and 4 in culture, but on malt agar it produced a few spores, which were not borne in acervuli but were scattered singly over the surface of the cultures. Some of them had five cells, some had six cells, but all had only one seta.

Saccardo (1907) distinguishes the genus *Pestalozzia* from the genus *Monochaetia* on the basis of number of setae—*Monochaetia* having only one and *Pestalozzia* having two to six. The cultures described above, which produced spores with one seta, were derived from single spores, which in turn were obtained from the same acervulus as were other spores which gave rise to races that produced spores with three setae. It is not likely that two genera of fungi would be fruiting in the same acervulus. Nor is it likely that *Monochaetia* spores would, by chance, so frequently lodge on an acervulus of *Pestalozzia*. It would seem more probable that these spores with one seta are just another variation within the species and that the old classification is not an entirely dependable one. Further proof of this statement is given later.

THE PRODUCTION OF VARIANTS

Triangular sectors, usually originating at the center of the colony and continuing out to the edge, appeared in some of the monosporous cultures. The sectors in the cultures were distinguished in various ways from the parents from which they originated: some were characterized by increased production of acervuli, some by decreased production; or the distribution of acervuli was different, the parent producing them in clear cut concentric bands and the sector producing them evenly over the surface; or the parent produced a multitude of tiny acervuli and the sector produced only a few large, prominent ones; or, as happened more often, the sector appeared to have lost the ability to produce spores in culture. Some of the sectors were distinguished by mycelial characteristics. A few of the sectors will be described.

In culture 1 of race 12 a very clear cut sector was formed in which few acervuli were produced until several weeks after acervuli had been formed

in the parent culture. In the parent culture acervuli developed so profusely as to literally blacken the surface. This parent culture and the mutant from it were carried through six generations in duplicate on malt agar and on Richard's agar. The parent culture consistently produced an abundance

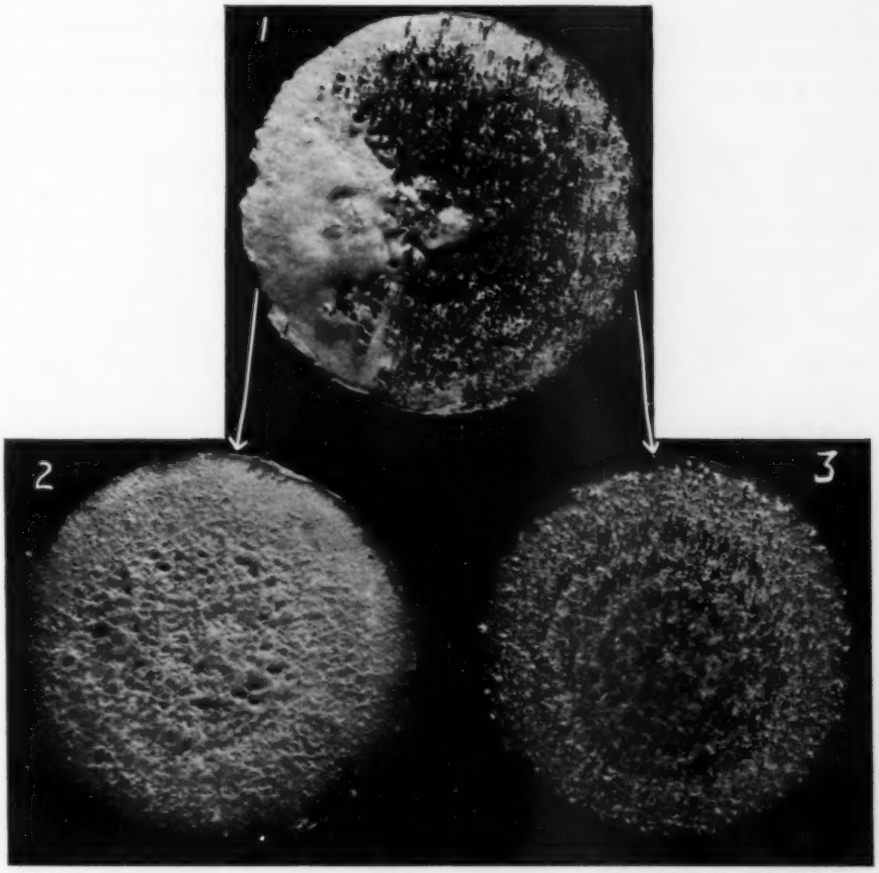

Fig. 3. *1*. A culture of race 12, on Richard's agar, showing a sector in which no spores are produced. *2*. A subculture from the sector. *3*. A subculture from the sporulating area. *2* and *3* are of equal age, grown on malt agar.

of acervuli within a week after being transferred, while the sector just as consistently failed to produce any acervuli for over three weeks after being transferred, and produced only relatively few after that. This parent culture and the subcultures from it are shown in figure 3.

Culture 1 of race 10 formed a sector which produced no acervuli, although the parent fruited abundantly. The parent and the sector were

grown side by side in duplicate flasks on malt, Richard's and Coon's agar, and the parent always produced numerous acervuli, while the cultures from the sector just as consistently failed to produce any.

Also, different strains suddenly arose in some cultures without manifesting their presence in any visible way. Inoculum from different parts of a culture which was to all appearances perfectly homogeneous in character resulted, in several instances, in subcultures which differed greatly in certain characteristics of growth. Such a difference appeared in one of the cultures of race 1 on malt agar. This culture had been grown for over five months, through several transfer generations, and up to this time had appeared to be a constant race. One of its characteristics had been the production of a large number of acervuli, from which the spores were exuded in a long, coiled tendrils. When transferred later for the purpose of making a comparative study, all the subcultures of this form on the different media produced only very few acervuli. In addition, the duplicate cultures on malt agar differed considerably from each other. In one the mycelium was white, abundant, slightly flocculent, and had several indistinct concentric rings. In the other the mycelium was less abundant, more appressed, had only one concentric ring, and was colored a light yellow. The agar was colored also by the yellow mycelium which grew through it. The yellow color was diffused and collected in granules throughout the protoplasm of the hyphae. This yellow variant has been grown on malt agar for five generations and on three other media for one generation, and it has constantly produced the distinctive yellow color.

From the foregoing descriptions of several of the cultures it can be seen that some races of this fungus are rather unstable even under ordinary cultural conditions. Other races, on the contrary, have been carried through numerous transfer generations for more than twelve months without displaying any visible inconstancy. Certainly not all of the variants which appeared in sectors and otherwise have been continued in culture long enough to enable one to state positively that their characteristics are constant. However, a number of them have been grown for more than a year on several different kinds of media, and during this time they have made no further permanent changes (excepting those in which sectors were formed) and the final cultures were exactly like the originals. Nor have any of the variants reverted to the parent types. From this it is only reasonable to assume that the other sectors will continue with the same degree of constance, except in instances where divergent forms may appear suddenly.

Many of the variants which appeared were characterized by a partial or total loss of sporulating ability, but some of them, on the contrary,

showed a gain in the ability to produce spores, as is illustrated in figure 4. It is possible, also, that this apparent gain may have been due to the loss of some factor which previously had inhibited the formation of spores.

Race 21 gave rise to an unusual and exceedingly interesting series of variants. Cultures of this race always produced such great numbers of spores that the surface was blackened, and little mycelium was visible. It first produced a variant which differed chiefly in a greatly decreased sporulating ability, scattered acervuli being borne in the mycelium above

Fig. 4. Race 2–1, on malt agar, showing a sector in which the sporulating ability is increased.

the surface of the agar. After several months a sector appeared in one of the cultures of this variant. In the sector numerous acervuli were borne, considerably more than in the parent, and they were always formed beneath the surface of the agar. In the parent, out of 200 spores, 21 had 2 setae, 158 had 3 setae, 20 had 4 setae, and 1 had 5 setae. In the sector, out of 200 spores, 30 had 1 seta, 155 had 2 setae, and 15 had 3 setae. None was observed that had more than 3 setae. Ten of the spores having only 1 seta were isolated, and in the cultures resulting from these isolations by far the largest number of the spores had only 1 seta; about two out of every hundred had two setae, and none was found with more than two setae. Not all

of these spores with one seta were normal in size, shape, or color. The aberrant ones had from two to six cells, and ranged from hyaline to normal in color, and sometimes the seta arose from the side of the end cell, instead of from the tip, and occasionally a spore was found in which the seta arose from the side of one of the median cells. Also, some spores appeared to be without a seta. These cultures were grown on malt agar and on Coon's agar, media upon which the parent cultures grew and sporulated very readily, so that any change which occurred was more likely in the genetic makeup of the fungus, not a temporary variation due to environment. This variant has been grown on malt agar for approximately a year, and the characters appear to be constant.

Several spores with two setae were isolated from this sector also, and the cultures derived from these isolations produced spores with two setae almost exclusively, the setae being considerably longer than those of the parent. In these cultures there were few aberrant spores, no more than are found normally in any culture, and the spores were borne above the surface of the agar, as in the parent.

The above variant which produced spores with two setae gave rise to another variant race, distinguished in culture by a marked increase in spore production, producing even more spores than race 21. In this variant, out of 200 spores, 1 had 3 setae, 164 had 2 setae, and 35 had 1 seta. The spores with one seta could be distinguished easily from the spores with 1 seta produced by the variant previously described, because the setae were much longer, and all of the spores were normal in shape. Single spores with 3 setae, 2 setae, and 1 seta were isolated from cultures of this variant, and the cultures resulting from all of them were similar, and, in all of the cultures, spores with 3 setae, 2 setae, and 1 seta were produced in approximately the same ratio as those of the original cultures of the race, namely 164:1:35. Thus, the range of variability of the variant race is greater than that of the parent, and here the spores with 3 setae and with 1 seta are only expressions of the normal range of this particular race. To sum up this series of unusual variants, there have been obtained from an original race bearing spores with 3 to 5 setae:

(1) A race which produces spores each with a single, short seta.
(2) A race which produces spores each with two long setae.
(3) A race which produces spores with 3 setae, 2 setae, and 1 seta.

Fig. 5. A series of variant races produced by sectoring, the order of their origin being indicated by arrows. Race 21 is the original, isolated from the longleaf pine. 21-1 is a variant produced by 21. 21-1-1 and 21-1-2 arose simultaneously in 21-1. 21-1-2-1 is a variant produced by 21-1-2. 21-2 is a later variant of 21. All cultures three weeks old, grown on malt agar.

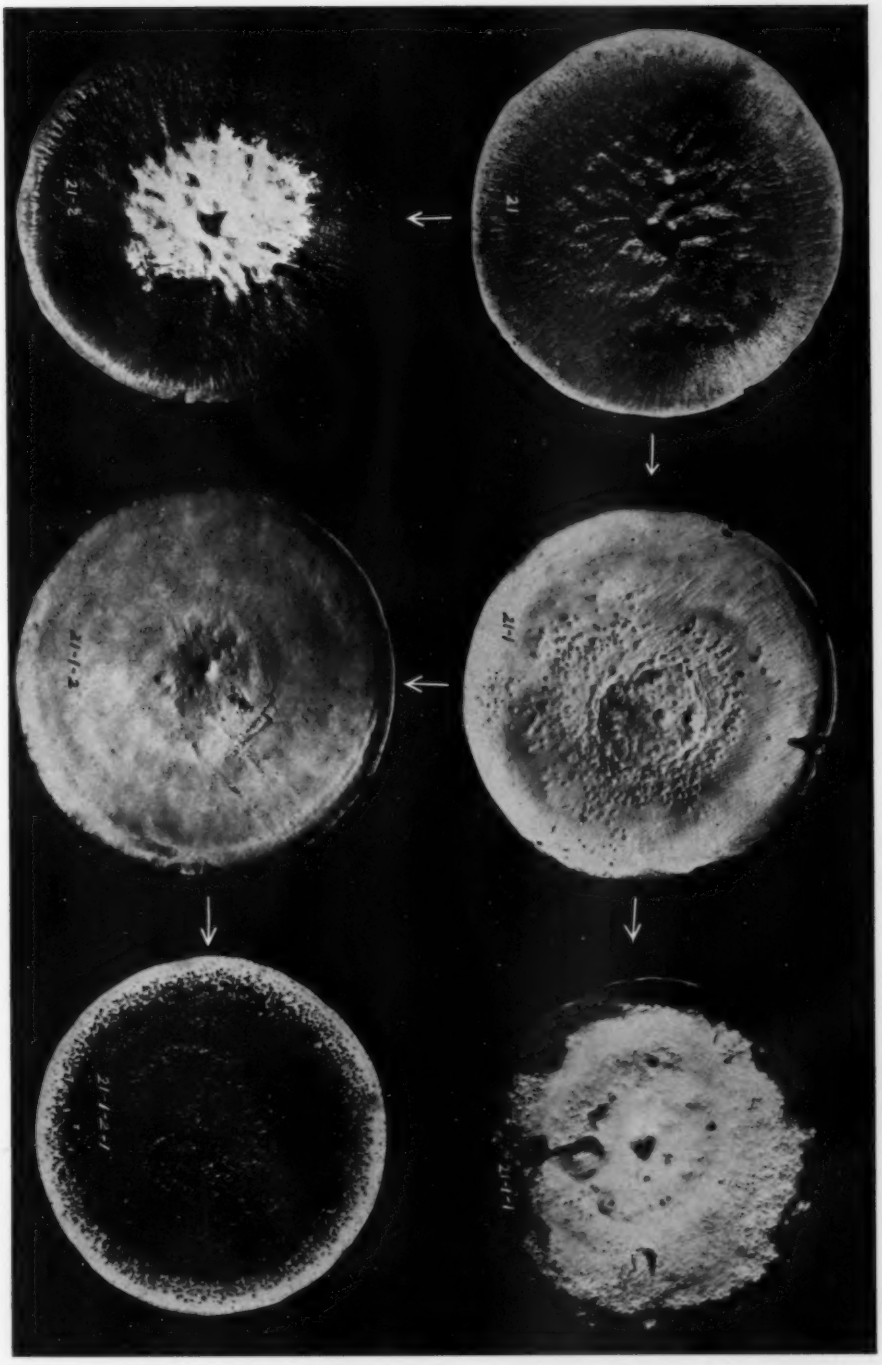

Fig. 5. See opposite page for explanation.

This series of variants and the spores produced by them are shown in figures 5 and 6.

The writer's experiments give little indication of the fundamental causes concerned in the origin of these new races. Results of staining show that some hyphal cells have one nucleus and some may have two, but it is not known whether this is significant in the origin of new races. The nuclear condition of the spores is not known. Until the facts are known in regard to the cytological phenomena associated with spore formation, spore germination, and the development of hyphae in these races, one can not state positively how these new races came into being.

The asexual condition of the fungus precludes the possibility of normal hybridization and segregation, at least immediately preceding the formation of sectors. It is possible, however, that sexual fusions occurred somewhere in the history of the fungus, and that the production of the present variants is the result of a very much delayed segregation of factors, although this assumption seems hardly credible. A heterokaryotic condition, originating in some previous sexual process, and continually becoming increased through hyphal fusions, could be responsible for the variants which have appeared. Or, as Brierley (1931) suggests, hyphal fusions in some of the Fungi Imperfecti may be sexual in nature. Either of the last two assumptions, if correct, would explain how a heterokaryotic condition might arise and continue, so that, instead of obtaining a pure line from a single spore, one might get a colony in which different hyphal cells would contain genetically unlike nuclei, or different combinations of unlike nuclei. The spores produced by these different hyphae would not be genetically alike, and the chance of isolating a genetically homogeneous race from such a colony, by isolating single spores, would be remote.

There is little reason to suppose that the origin of variants is limited to one single cause, and it may be that the variations in these races can not be adequately described unless all of the above assumptions, including mutation, be taken into consideration.

Certainly it would be somewhat illogical to assume that these relatively permanent changes in the organism were only adaptations to variable or abnormal environments, even though the environment may have been a

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Fig. 6. Photomicrographs of spores of different races. Two upper pictures: Left, race 2; right, race 10, showing difference in length of setae. Four lower pictures: The numbers indicate the races (shown in Fig. 5) from which the spores were taken; the arrows indicate the order in which the variants appeared. Note the single, short seta on each spore of 21-1-1, the two long setae of each spore of 21-1-2, and the single long seta of two of the spores of 21-1-2-1. Races 21-1-1, 21-1-2, and 21-1-2-1 were photographed with a higher magnification than the others.

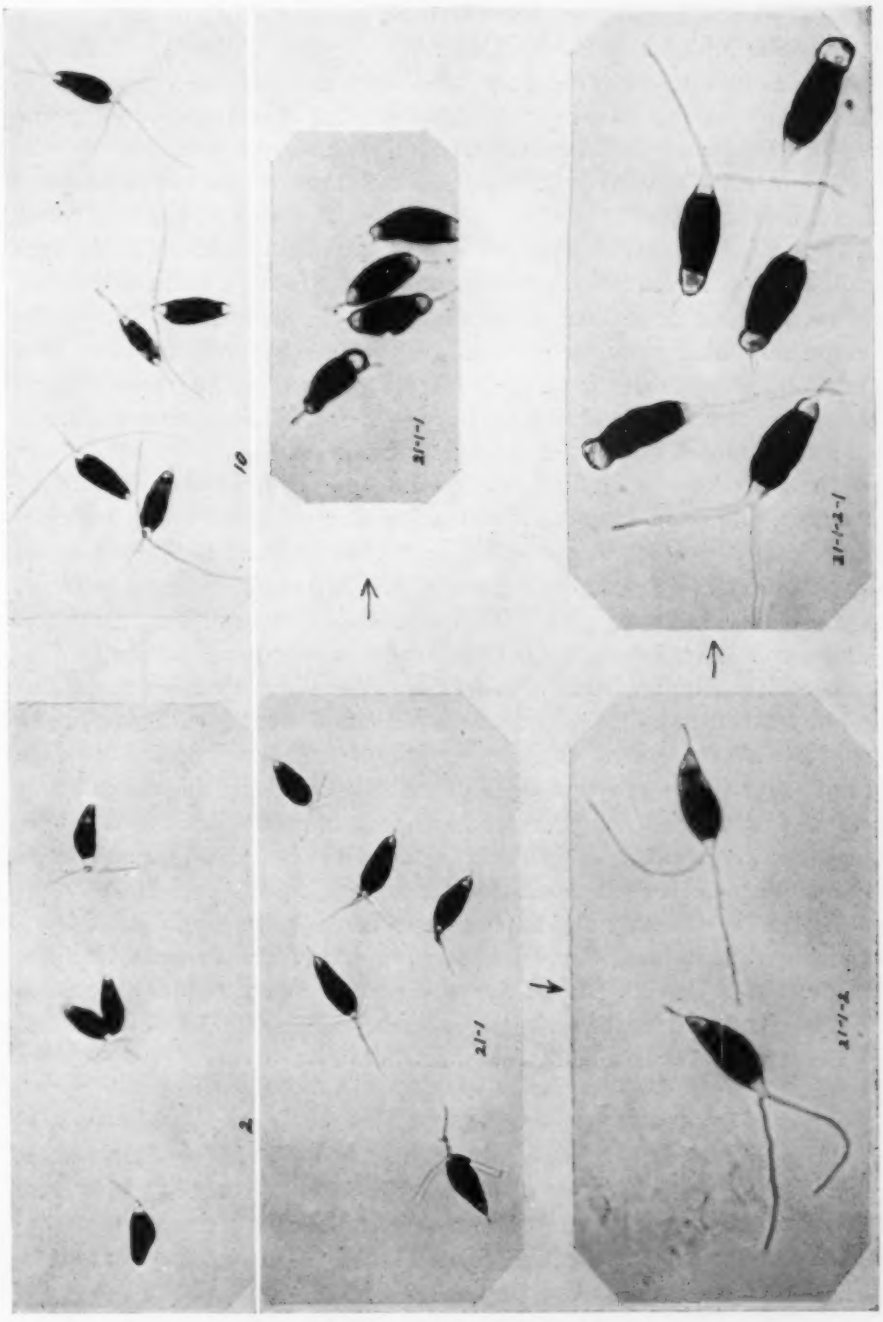

Fig. 6. See opposite page for explanation.

factor in the production of these variants. Races which arise fortuitously at irregular intervals, and which retain their newly acquired characters, hardly can be considered ordinary, temporary modifications. Especially is this true of variants showing new morphological characters, of which the race bearing spores with only one seta is a striking example.

The origin of a variant differing so much from the parent in morphological characteristics that it could be placed in a different genus, seems significant. There are two possible explanations of this: either the new race is a previously undescribed variant of *Pestalozzia funerea*, and the limits of the species must be widened accordingly, and the genus *Monochaetia* considered no longer valid, or else the author has observed the birth of a species of *Monochaetia* from a species of *Pestalozzia*. The race bearing spores with two setae, and the race bearing spores with one, two, and three setae are evidence in favor of the former interpretation.

The evidence presented proves that new races of *P. funerea* have arisen in culture, differing from their parents either physiologically, or morphologically, or both. These new forms have retained their characters, except when they again produced variants. Although the mechanism of their origin is not known, mutation, in the sense in which Baur (1922) and Stakman et al (1929) used the term, would seem to explain the process more exactly than any other. An academic discussion of the appropriateness or correctness of the several terms which different investigators have applied to similar phenomena in other fungi is hardly within the province of this paper. Thorough discussions of the subject, illustrating the different points of view concerning the occurrence of mutation and saltation in fungi, are given by Brierley (1922), Brown (1926), and Stakman et al (1929). But whether the described changes, both physiological and morphological, be called by one name or another, is not so significant taxonomically as is the fact that these changes occur. The essential fact for taxonomists is that *P. funerea* has a wider range of variability than has been ascribed to it in the past, that it consists of a number of races, and that new races are continually being formed.

PATHOGENICITY

There is considerable conflict of opinion in the available literature in regard to the pathogenicity of *Pestalozzia funerea*. Some workers have found it to be a saprophyte, while other investigators, studying its pathogenicity on the same and closely related species of trees, have found it to be a parasite of some economic importance.

Spaulding (1907) published a report of a damaging needle blight of *Pinus ponderosa* and *Pinus divaricata* caused by *P. funerea*. He inoculated

one-month-old seedlings of *Pinus ponderosa* and the disease was produced. Infection failed to appear on the one-year-old stock which he inoculated. Hartley (1913) isolated *P. funerea* from diseased jack pine and Rocky Mountain pine. He inoculated one-year-old white pine seedlings with spores obtained from these cultures, but no infection appeared.

Wenner (1914) found two parasitic forms, which have been discussed previously in this paper. One form was isolated by Prof. Graves from the stems of a badly diseased *P. Strobus* near New Haven, Connecticut. Other fungi were present in the diseased tissues. The second form was isolated by Wenner from the leaves of a five-year-old *P. Strobus* which had been kept in the greenhouse for several months. He inoculated several different species of conifers with the spores produced in cultures. Infection resulted on one-month-old, one-year-old, and three-year-old white pine, one-month-old and two-year-old Norway spruce, and on one-year-old hemlock.

Graves (1914) reported a twig blight of Norway spruce which he states may have been caused by *Pestalozzia funerea*. Fischer (1912) found *P. funerea* parasitic in the leaves of *Pinus canariensis*, *P. longifolia*, *P. insignia*, *P. Massoniana*, *Cupressus lusitanica*, and *C. Lawsoniana*, and *Casuarina leptoclada*. Guba (1929) states that *Pestalozzia funerea* is restricted to plants of the family Pinaceae.

Thus it can be seen that there are divergent opinions upon the relation of this fungus to its host plants. To ascertain the role which this fungus played in the blighting of longleaf pine needles and to find out if it were capable of parasitising other species of pines several inoculation experiments were made. Seven different species of conifers were used. The seedlings were grown in the greenhouse and were from four to six weeks old when inoculated. About 200 Douglas fir (*Pseudotsuga taxifolia* Brit.) seedlings, and 100 each of white pine (*P. Strobus* L.), Norway pine (*P. resinosa* Ait.), and jack pine (*P. Banksiana* Lamb.), and 80 longleaf pine (*P. palustris* Mill.) seedlings were placed in inoculating chambers in the greenhouse and inoculated with *Pestalozzia funerea*. Spores from all the spore-producing forms of the fungus were taken from the cultures, suspended in distilled water and sprayed onto the leaves with an atomizer. The plants were left in the inoculating chambers for four days, then taken out and set on benches in the greenhouse. No infection appeared. The experiment was repeated with an equal number of trees of each of the species first used plus six slash pine (*P. caribaea* Morelet) seedlings about eight inches high, and about 150 Engelmann spruce (*Picea Engelmanni* (Parry) Engelm.) which had been grown in the greenhouse and were about two weeks old. Here also no infection resulted. From this it seems likely that those races of the fungus investigated by the writer are saprophytic and en-

ter the pine needles only after they have been injured by some other cause. This opinion would be borne out by the fact that *Pestalozzia* was found by the writer only on those needles of longleaf pine which had already been invaded and partially killed by *Septoria*.

CONCLUSIONS

Pestalozzia funerea comprises many races or physiologic forms. This statement is attested to not only by the results of the writer's cultural studies of the fungus, but also by the lack of agreement in the results of other investigators who have studied the pathogenic capabilities and cultural characteristics of the organism. All the races described in this paper were isolated directly from two longleaf pine seedlings collected in Louisiana, or appeared as variants in these cultures. If more material, from other parts of the country or from other parts of the world, were collected, it is probable that more strains would be found. Not all of the forms which were discovered have been studied long enough to prove their existence as separate entities within the species, but the characteristics of a number of them have been established beyond all doubt.

The appearance of distinct and apparently permanent variants in some of these races has been observed but the mechanism by which they arose can not be known until more is known about the cytological phenomena involved.

The appearance of a sector which produced spores with only one seta may be of considerable mycological significance. The validity of the writer's previous inclusion in the species of forms which produced spores with one seta and five to six cells may have met with considerable doubt and some incredulity on the part of those who would have a place for everything and everything in its place, but, since these spores with only one seta were isolated from the host tissue and also obtained as a result of sectoring in cultures having spores with three setae, there is not much doubt that *Pestalozzia* occasionally does give rise to such forms. This should serve to clarify slightly the haze of uncertainty with which this group of fungi is surrounded. It seems to the writer that *P. funerea* is rather unstable, and, if this be true, it is far better to admit the fact, distressing though it may be, than to force rigid limitations upon a labile organism. If we are to adjust our conceptions to fit these new facts we must either widen the limits of *Pestalozzia* sufficiently to admit these new forms, and consider the genus *Monochaetia* invalid, or else concede that occasionally a species of *Pestalozzia* may give rise to a species of *Monochaetia*.

Pestalozzia funerea occasionally has been reported pathogenic upon different species of coniferous trees throughout the world. The writer's

inoculations of white, Norway, jack, longleaf, and slash pines, Douglas fir, and Engelmann spruce did not result in infection. From this it may be concluded either that the fungus is parasitic only under certain conditions, which were not maintained in these experiments, or that there are some strains within the species which are parasitic and others which are saprophytic.

SUMMARY

1. Fifteen cultural races of *Pestalozzia funerea* were obtained by isolating 150 conidia from needles of longleaf pine. These races were distinguished from one another on culture media by the following characteristics: rate of growth, abundance, color, topography, and zonation of the surface and aerial mycelium, abundance, distribution, and size of acervuli, size, color and shape of spores, length of setae, and number of setae.

2. About ten distinct variants arose in the form of sectors in the above races and were distinguished from the parents and from each other by the characteristics listed under (1).

3. Three races obtained from spores produced in pustules on the needles of longleaf pine, and two races obtained from sectors in culture, conformed to the description given for *Monochaetia*, thus showing that our previous conception of this genus is scarcely tenable.

4. Seven species of conifers were inoculated with spores of different races of the fungus. None of the races were parasitic under the conditions maintained in the experiments.

UNIVERSITY FARM
ST. PAUL, MINNESOTA

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INDEX TO AMERICAN BOTANICAL LITERATURE
1930–1932

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